

The Library's on-line activities include building a database of community organizations and a calendar of events, and compiling a "Seattle Facts" database. The library also provides access to the Washington State Legislature Public Access System, the City of Seattle Public Access Network, and the city's geographic information system, as well as important local community documents.

In addition to providing access, libraries have extensive experience and distinct capabilities in locating and organizing information. They can apply these skills in identifying, evaluating, and synthesizing information available through the NII as a service provided to community members, schools, and businesses.

**Community centers.** Community centers represent another possible entity—in addition to schools and libraries—that can advance the lifelong learning needs of communities, provide public access to the information superhighway, and even deliver social services. As with libraries, the applications, benefits, infrastructure options, and costs to provide NII access will derive from the specific role of the center in its community.

For the purposes of this discussion, we define a community center as a physical or electronic location where community members go to meet others, learn, play, or access information resources or social services. This broad definition encompasses a range of locations and a wide spectrum of potential roles. For example, the role of one community center could be to offer convenient, affordable access to the NII for the general public while another could be to provide targeted, programmatic access to the NII for at-risk groups. An example of the former role, Smart Valley in California is experimenting with placing Internet stations in a range of public locations including shopping centers, post offices, and town halls in order to better understand behavior and usage patterns. Examples of the latter role include a number of programs to expose inner city youth and other disadvantaged groups to technology. Plugged In of East Palo Alto, California, originally focused on at-risk youth in neighboring areas, has been expanding through partnerships to work with battered women's groups and rehabilitation centers. Currently, Plugged In offers programs on using computers, accessing the Internet, and working with various software packages. Some communities with limited resources may prefer to connect community centers ahead of schools or libraries. For example, a representative of a Native American community told us that Native Americans would be more inclined to accept and use NII-based tools if they were introduced in the tribal community centers rather than the public schools.

Some K-12 schools are serving as learning centers for members of their communities by providing after-hours access to distance learning and computer facilities. Mississippi's Project LEAP (Learn, Earn, And Prosper) is one such program; it uses satellite-based transmission in 200 K-12 schools to broadcast courses in reading, GED preparation, workplace readiness, and life-coping skills. These programs are broadcast after school hours from 4 to 9 pm.

LIBRARIES  
COMMUNITY  
CENTERS AND  
COMMUNITY  
NETWORKS

**Community Networks.** In the broadest sense, a community could seek to be "wired" by networking a range of physical community centers as well as creating electronic communities that connect individuals or groups to each other and to community resources. While most are just in the planning stage, some community-wide networks are in operation today. The DIANE Project in Tennessee connects nearly 30 different institutions including universities, primary and secondary schools, libraries, science groups, local community centers, and small business groups.

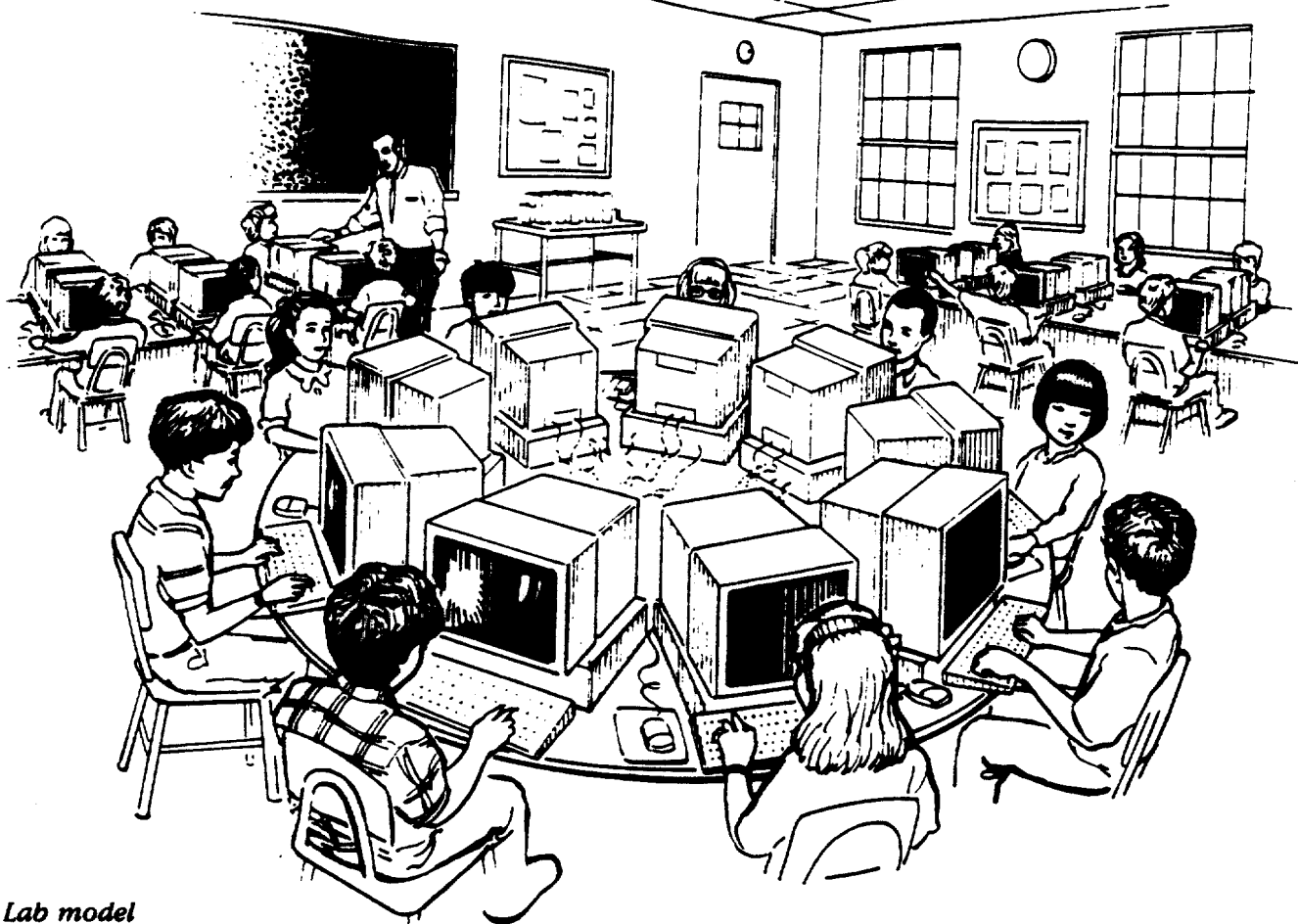
Other communities have started by building community electronic bulletin boards that include public and private industry job listings, city permit applications, vehicle registration information, resources for starting up and growing small businesses, and announcements of emergency procedures. The La Plaza Telecommunity in Taos, New Mexico, is an on-line service and electronic community that provides educational services through Internet resources and distance learning; improved access to health care/medical information and resources (including Diabetes Knowledge Base for the local Pueblo Indians and prenatal care in response to the high incidence of teenage pregnancy); an electronic communications medium for debate of government and societal issues; and access to government information (including job listings from the New Mexico Department of Labor Service Center). Increasingly, discussions in some communities and among some government officials are focusing on how a broad set of social services could be delivered electronically, including welfare, health care, and home education.

## INFRASTRUCTURE OPTIONS AND COSTS

While the benefits of connecting to the NII appear to be significant, many policymakers and educators are concerned about how much it would cost to capture some or all of these benefits. To provide a framework for thinking about the range of options for deploying technology infrastructure in the public K-12 schools, and the costs of those options, we developed a sequence of models for deployment. These models represent prototypical infrastructure deployment choices that schools are actually making; they also illustrate the fundamental economic breakpoints among options.

The models focus on networked computers linked together and to the NII via wireline connections, except in rural locations where wireless connections are more feasible.<sup>22</sup> While deployment would actually take place at varying speeds in different schools and districts, we made the simplifying assumption here that each model will be implemented evenly over either a five-year or ten-year period (i.e., by 2000 or 2005). For each model, we evaluated the costs in detail across six infrastructure elements: (1) the connection to the school (i.e., the wide area networks that will connect schools to each other, to their district offices, and to the NII); (2) the connection within the school

<sup>22</sup> Although at a later point in the dissemination of broadband technology to residential communities interactive television sets may rival networked computers as a base for connecting to the NII, we focused on computer-based technology because it is widely available today. By the same token, although satellite and cable both represent important alternatives for connection, we focused on telephone connections because they offer two-way interactivity and are ubiquitous.



*Lab model*

(i.e., local area networks that will link computers within the given schools); (3) the hardware, including the computers, printers, scanners, and other equipment needed for full functioning of the technology; (4) content, including software and on-line service subscription charges; (5) professional development for teachers; and (6) ongoing system operations. Both video and voice options were evaluated as add-ons to the computer-based options.

### **Models of infrastructure deployment<sup>23</sup>**

Briefly, the key features and associated costs of the computer-based models are as follows (see Exhibit 3: "Model Features" and Exhibit 4: "Estimated Cost of Deploying and Operating Infrastructure"):

- The basic "Lab" model envisions connectivity at the lab (or multimedia room) level for every public K-12 school by the year 2000. For each school, it includes 25 networked computers connected to the NII via 10 standard telephone lines (see Drawing: Lab model). This option only gives limited, scheduled access to teachers and students—for example, a given class of

<sup>23</sup> A detailed description of the models, their underlying assumptions, and the methodology for estimating costs may be found in Appendix A.

Exhibit 3

**MODEL FEATURES****Computer-based infrastructure****Lab**

- Single room
- 25 computers
- Ethernet LAN in lab
- 10 telephone lines

**Lab Plus**All of the above, *plus*

- Computer and modem per teacher

**Partial classroom**

- Half of classrooms:  
1 computer per 5 students
- Ethernet LAN across and within all classrooms
- T-1 connection

**Classroom**All of the above, *plus*

- All classrooms:  
1 computer per 5 students

\* Extent of equipment, content, professional development, and support varies by model

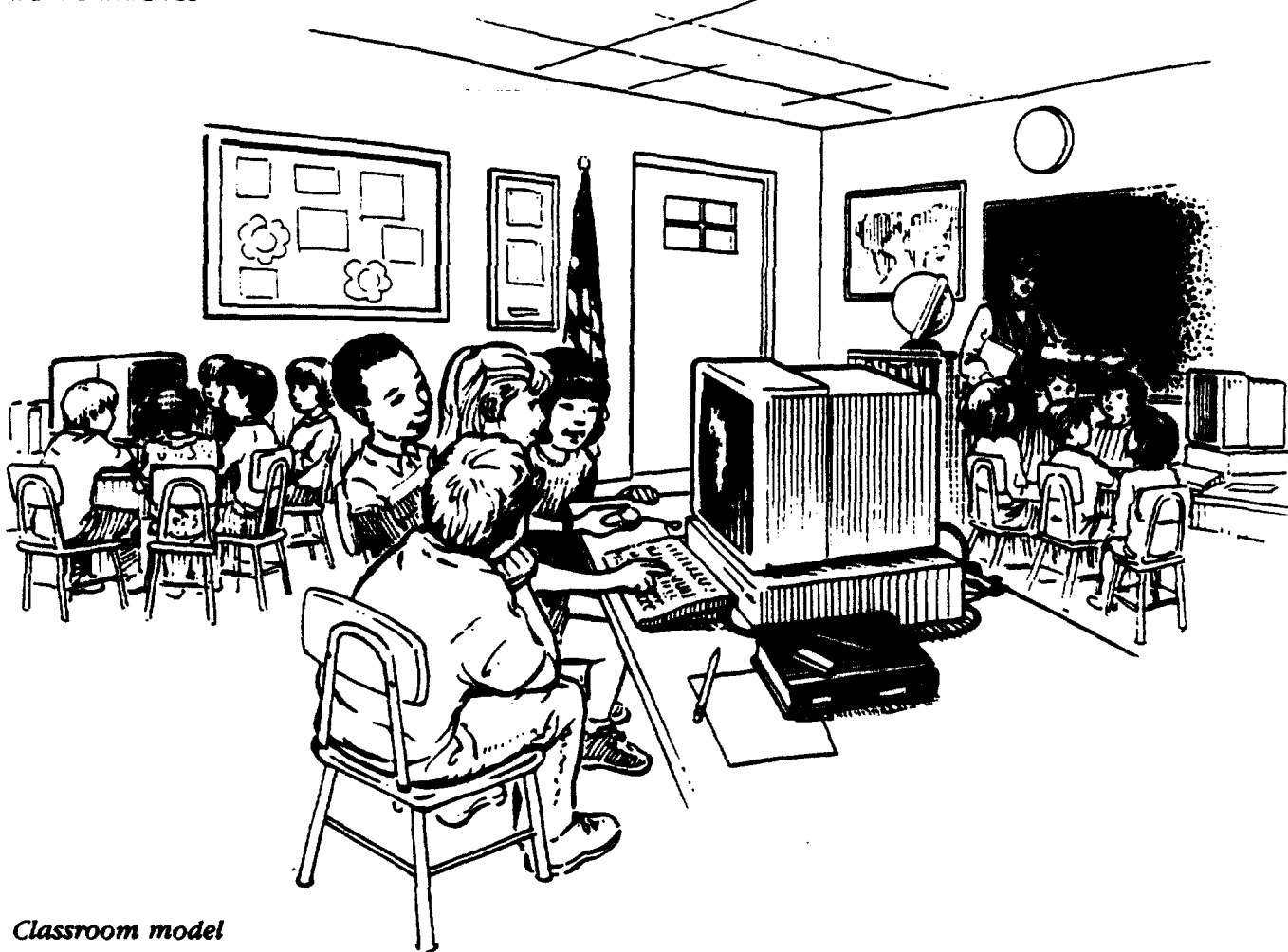
Exhibit 4

**ESTIMATED COST OF DEPLOYING AND OPERATING INFRASTRUCTURE****Computer-based infrastructure**

Model	Total initial deployment \$ Billions	Annual operation and maintenance \$ Billions	Public K-12 spending in final year* Percent	Deployed by year
Lab	\$11	\$4	1.5%	2000
Lab Plus	22	7	3.0	2000
Partial Classroom	29	8	3.4	2000
Classroom	47	14	3.9	2005

\* Reflects increase in education budget as forecasted by Department of Education (averages 5.6% per year through 2005 including inflation)

Source: National Center for Education Statistics; McKinsey analysis



*Classroom model*

students might be able to use the lab for one hour a day. Such intermittent usage requires a high level of commitment by all involved parties to achieve an effective level of integration into the curriculum. This type of set-up may be most appropriate for schools that are just beginning to experiment with technology and connectivity or where building basic computer and networking skills is the main focus.

One-time purchase and installation costs for the Lab model—deployed nationwide in all public K-12 schools—would total \$11 billion during the five-year deployment period, while ongoing operation and maintenance costs would build over the deployment period to \$4 billion per year once the infrastructure is fully in place. Another way of thinking about the cost is that it would represent 1.5% of the public K-12 education budget in the final year of deployment (the year that costs would reach their peak).<sup>24</sup>

<sup>24</sup> The final year of deployment represents the largest funding challenge. In the final year, the school is incurring the full load of ongoing operations and maintenance costs, in addition to the final installment of the one-time purchase and installation costs. Accordingly, costs in the final year of deployment represent the highest level that costs reach. For three of the four computer-based models presented in this report, the final year of deployment is 2000; for the Classroom model, it is 2005. Appendix A contains two more ways to represent the costs of deployment: per school and per enrolled student (see Exhibit 17: "Different Representations of Model Costs").

- In addition to all the technology assumed by the basic Lab model above, the intermediate "Lab Plus" model adds one computer and modem for each teacher. The rationale is to give teachers adequate exposure to the technology to expedite skill building and adoption of the technology.

One-time purchase and installation costs would total \$22 billion during the five-year deployment period, and ongoing operation and maintenance would cost \$7 billion per year once the technology is deployed. Costs would represent 3.0% of the public K-12 budget in the year 2000, the final year of deployment.

- The "Partial Classroom" model assumes that half of each school's classrooms are connected with networked computers by the year 2000. The ratio is the same as with the Classroom model below: 5 students per computer with a T-1 connection (or substitute). Neither this model nor the Classroom model includes a computer lab. The Partial Classroom model is designed to illustrate a less costly variant—and possible step on the path—to the Classroom model. It also presupposes that some classes or teachers may be better starting points for deployment than others. For example, a school may choose to begin deployment in math or science classes or with teachers who appear particularly open to experimentation and change.

One-time purchase and installation costs would be \$29 billion over the five-year deployment period; ongoing operation and maintenance expenditures would equal \$8 billion per year once the technology is deployed. Costs would represent about 3.4% of the public K-12 budget in the year 2000, the final year of deployment.

- The "Classroom" model connects every classroom of every public K-12 school to the NII through networked computers, at a ratio of 5 students per computer, using a T-1 line that transmits data, voice, and video at 1.5 mbps (or substitute if T-1 is not economically feasible). In this set-up, students work in small teams around the computers (see Drawing: Classroom model). Placing the computers directly in the classroom makes it possible to integrate the technology more closely into the curriculum than if the computers were in a lab. Teachers are able to incorporate computers and the NII in teaching the full range of subjects throughout the course of the school day, and students have easy access to the technology.



*Distance learning*

One-time purchase and installation costs for this model would equal \$47 billion over the ten-year deployment period, while ongoing operation and maintenance costs would build over the deployment period to \$14 billion per year once the infrastructure is in place. Costs would represent 3.9% of the public K-12 budget in 2005, the final year of deployment.

- While we also considered a "Desktop" model that put a networked computer on every student's desk, it involved substantially greater costs. Initial installation costs were more than  $3\frac{1}{2}$  times as high and ongoing costs  $2\frac{1}{2}$  times as high as those of the Classroom model. For this reason, we did not examine the Desktop model in depth, even though the model might be desirable from an educational standpoint for schools or districts that can afford it. In fact, a few pioneering schools and districts, like Hueneme, have installed infrastructure similar to this model.

These models are based on weighted average costs taking into account different types of schools (e.g., old versus new, rural versus

urban). All the models also take into account the currently existing infrastructure—that is, they make allowance in the costs for the computers and other infrastructure already deployed in the schools. Finally, they include estimates of future price declines in computers and other technology items.

### Adding video and voice capabilities

Costs for video equipment and operation, and for classroom telephones and voicemail, were calculated separately. Video equipment can deliver a range of educational benefits, from providing students access to educational materials available on videotape or videodisc to enabling classroom “field trips” to museums and historical sites. Distance learning, in which schools use video technology to allow students to participate long-distance in courses offered at other schools or colleges, can be especially valuable for rural or inner city schools (see Drawing: Distance learning).

The cost to provide video varies widely from installation to installation, however. On average, business-quality video, the quality of video most commonly used for videoconferencing today, can be added to computer-based deployment for a relatively nominal amount—for example, an additional 0.3% of the public K-12 budget for the Classroom model (see Exhibit 5: “Dedicated Video Infrastructure”). But some educational experts advocate the use of professional quality video where possible because it is more engaging for students,

Exhibit 5

### DEDICATED VIDEO INFRASTRUCTURE\*

Estimated Costs

\$ Billions



\* Incremental investment to classroom model; both video infrastructure options include professional development and systems operation costs

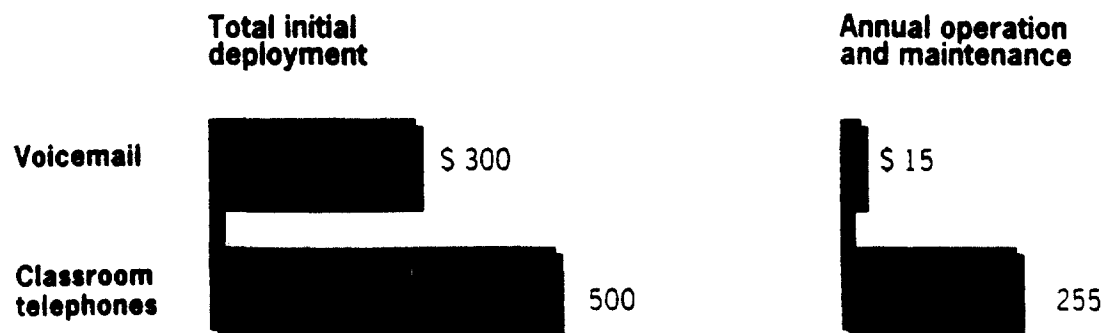
Source: Case studies; McKinsey analysis

Exhibit 6

# DEDICATED VOICE INFRASTRUCTURE

Estimated costs

\$ Millions



Source: Interviews; McKinsey analysis

who can be distracted by the jerky movements common to business-quality video.<sup>25</sup>

Installing high-resolution, professional-quality video increases the cost of deployment significantly. Some schools have spent up to \$200,000 on equipment to create state-of-the-art facilities, and arranged for high bandwidth connections to produce better sound and images. For example, the Guilford County School District in North Carolina equipped all 16 of its high schools with high-quality equipment at about \$100,000 per room, and connected this equipment to North Carolina's fiber optic information highway. Typically, Guilford County schools use their video system to deliver distance learning of advanced subjects like physics to students in rural areas of the district. Assuming less equipment investment than in the Guilford County example (approximately 35% less), a low-end professional-quality video facility would add approximately 30% to the Classroom computer-based model—or 1.2% of the public K-12 budget in the final year of deployment.

<sup>25</sup> Videoconferencing allows an image from a remote site to be displayed on a local party's television or computer screen, while a local camera simultaneously transmits an image to the remote party's screen, somewhat like a TV phone call. Business-quality videoconferencing typically features full-screen images, although these can be slightly fuzzy and may exhibit jerky motion, which some argue can fatigue viewers. Professional-quality videoconferencing, by comparison, features full-screen, full-motion, crisp video images. Unfortunately, it is also substantially more expensive than business-quality videoconferencing. Another video application, desktop conferencing, is growing increasingly popular. In desktop conferencing, individuals have video windows on their computer screens, with slightly fuzzy images and jerky motion. Desktop video is best used when face-to-face contact is required or body language is important, but it is too limited for classroom uses such as distance learning.

Classroom telephones and voice mail can also be added to the computer-based models relatively inexpensively (see Exhibit 6: "Dedicated Voice Infrastructure"). If the wiring for the telephone system is installed at the same time the local area network for the computers is installed, the additional costs are low. Telephones would add less than 0.1% to the funding challenge for the Classroom model if installed in conjunction with classroom wiring for computers, and voice mail would add even less than the costs incurred for telephones. Installing the telephones separately, however, would raise the overall price tag substantially.

### **Key findings about deployment costs**

The models illustrate clearly that the biggest financial tradeoff hinges on how far into the school the technology is deployed—to the lab, the classroom, or all the way to each student's desk. But perhaps the most important finding from analyzing these models is that connecting public K-12 schools to the NII seems financially feasible. Connecting a computer lab to the NII in every public K-12 school by the year 2000 would require only 1.5% of the expected K-12 education budget in 2000 (the peak year of expenditures). By comparison, about 1.3% of public K-12 spending is already devoted to similar technology today. Thus, the Lab model could be deployed at a cost of 0.2% more than the public K-12 schools are currently spending on technology. Even connecting every classroom of every public K-12 school by the year 2005 would require only 3.9% of the expected K-12 education budget in 2005.

Analysis of these models reveals some other key insights about deployment costs, regardless of which model is selected (see Exhibit 7: "Cost Components"):

- Not surprisingly, purchase and installation of hardware constitute the largest upfront cost. On average, approximately 55% of the total hardware cost can be attributed to computers; 25% is printers, scanners, security and furniture stations; and 20% is retrofitting (upgrades for electrical and HVAC—heating, ventilation, and air conditioning).
- Perhaps less obviously, support and development for teachers and other school professionals constitute the largest ongoing cost during the 5 to 10 year period of deployment. Professional development includes formal training programs, on-the-job support from curriculum specialists, and use of the technology on the teacher's own time.

Exhibit 7

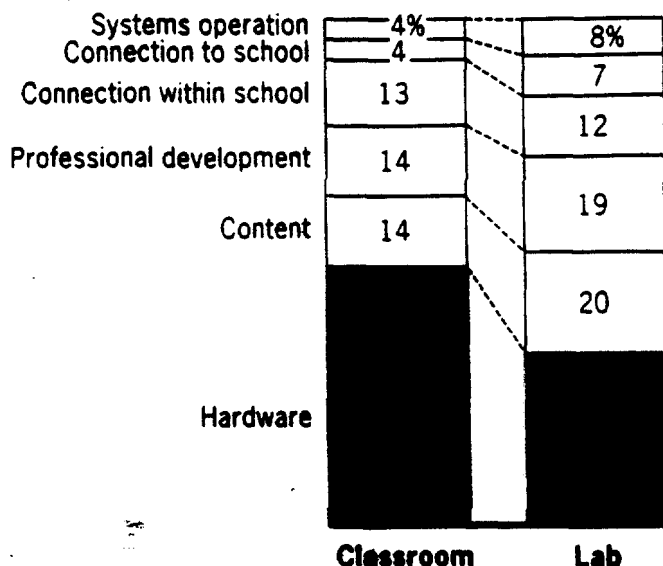
**COST COMPONENTS**  
Computer-based infrastructure  
Percent

Major cost drivers

**Total initial deployment**

100% = \$47 billion

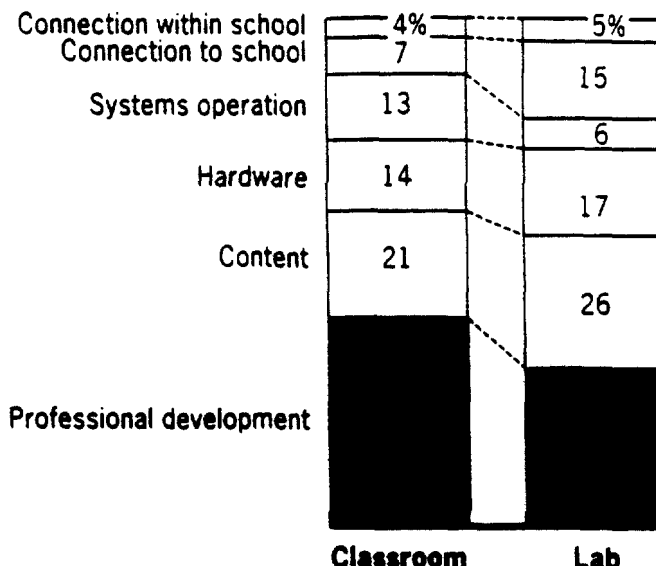
\$11 billion



**Annual operation and maintenance**

100% = \$14 billion

\$4 billion



Source: McKinsey analysis

- The cost of connection per se is a relatively small portion of the overall expenditures. In the Lab model, the portion attributable to connection to the school is 8% for initial deployment and 15% for ongoing costs; for the Classroom model, it is only 4% for initial deployment and 7% for ongoing costs. However, increased levels of usage over time could ultimately drive the relative cost of connection up. Depending upon the size of the up-front costs, the usage charges thereafter, and the potential need to upgrade for higher capacity at a later date, schools may want to consider installing a connection that has greater capacity (for supporting multiple users and carrying large amounts of data) than they need today or even project they will need in a few years.<sup>26</sup>

<sup>26</sup> For example, in certain states, some schools may find it more cost-effective to implement 5 ISDN lines instead of 10 POTS lines. The 5 ISDN lines, like the 10 POTS lines, permit 10 concurrent users—but with double the performance capability and the ability to handle video. Depending on the state tariffs, the 5 to 10 year cost for this additional capability could be fairly minimal—in fact, the extra \$4000 in installation charges above that for telephone lines is likely to be quickly recouped in lower usage charges.

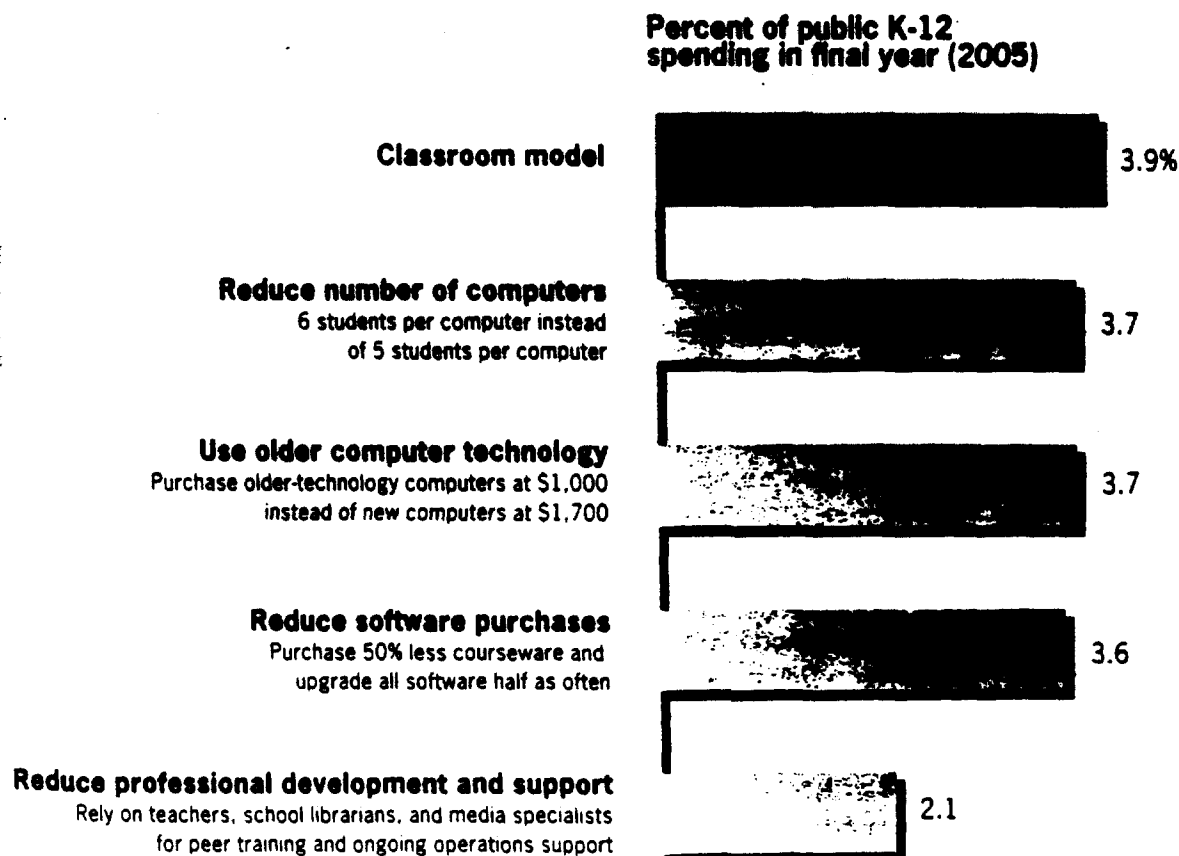
- Adding video equipment would not necessarily increase deployment costs substantially, depending on the quality of equipment selected.
- Classroom telephones and voice mail could be added fairly inexpensively—if the wiring is installed at the same time as the local area network for the computers.

Naturally, individual schools will deviate from the averages shown in the models. In particular, installation may be more expensive for older schools and connection could be more costly for rural schools. Older buildings are more likely to require substantial retrofitting in order to accommodate the installation of both hardware and local area networks. We calculated that, for the Classroom model, the local area network and hardware installation for a “typical” school implementing the Classroom model would cost approximately \$375,000 per school.

Exhibit 8

## POSSIBLE LOWER-COST MODIFICATIONS TO CLASSROOM MODEL

Percent



But these costs could be as low as \$275,000 for new schools that have adequate HVAC capacity and wiring already built-in; they could also be as high as \$800,000 for older schools with asbestos, inadequate electricity, insufficient HVAC capability, and a building structure that will not support a wireless local area network. Rural schools may find the wide area connections to be unavailable or prohibitively expensive. For example, a T-1 connection in a rural area could cost twice as much—\$15,000 per school per year—as a T-1 connection in a non-rural area.

### **Trade-offs**

While we believe that the models selected for analysis define a useful spectrum for consideration, they are only a few of many options. Individual schools and districts might choose other models and make different trade-offs between costs and potential benefits (see Exhibit 8, previous page: "Possible Lower-Cost Modifications to Classroom Model"). With all such choices, schools should carefully consider whether cost reductions will be sufficient to warrant the accompanying loss of educational benefits. For example, purchasing lower cost computers could substantially reduce initial deployment costs. However, computer capabilities dictate the range of applications students and teachers can use. Likewise, reductions in funding for teachers' professional development could significantly reduce the largest source of ongoing costs during the deployment timeframe, and yet teacher skill building is one of the most essential elements of effective implementation. Trade-offs could also be made between exploiting current technology versus experimenting with or waiting for more advanced technology.

## CHALLENGES TO CAPTURING THE BENEFITS

The pace of deployment for any of these infrastructure models depends on three factors: funding availability, professional development, and courseware availability. Schools' ability to acquire computer equipment and network their facilities is primarily a matter of obtaining funding, but the value of the hardware and network connections depends on the quality of the applications and teachers' ability to integrate them into the curriculum. In other words, simply raising the money for the physical infrastructure is not enough: teachers, courseware developers, and community leaders must come together if the benefits of the infrastructure are to be realized.

Consequently, deployment presents a number of challenges for schools. First, districts need to raise funds for installation and ongoing operations in the face of competing demands for funding and budget cutbacks. Second, teachers need both incentives and time to develop the new skills required to make effective use of network technology through both formal training and hands-on experience in the classroom. Third, a wide selection of high-quality multimedia courseware needs to be made available to supplement the traditional textbook-based curriculum.



These challenges increase as schools progress from the relatively simple goal of promoting computer literacy to more ambitious efforts to use network technology as an integral part of the curriculum. While a lab may be sufficient for basic computer-based assignments, networked computers need to be in the classroom if they are to be used as part of the day-to-day learning experience. Broad deployment, in turn, raises the funding hurdle and puts much greater demands on teachers. A broader selection of courseware is also required to meet the needs of a wide range of subjects and grades.

Although these challenges are substantial, they are surmountable. Funding needs can be met by a combination of reducing costs, reprogramming existing educational funds, and obtaining funds from new sources. Teachers' skills will develop with appropriate incentives, on-the-job experience, and in-service training; revised certification requirements and teacher college curriculums will also help reinforce this goal. Finally, the courseware market will develop as demand mounts from schools that have deployed the infrastructure and teachers search for new on-line content.

### **Meeting the funding challenge**

The funding challenge is substantial both because of the limited access most schools have today to the basic infrastructure, and because of the fiscal pressures at work in the current budgetary environment. Setting budget priorities among many competing demands for funds—and securing grants, donations, and subsidies—requires strong leadership at many levels and a clear, compelling vision, as well as a good dose of creativity and persistence.

**Limited current infrastructure.** When it comes to basic infrastructure, most schools are starting from a low base. While many schools have computers, as of 1994 over 85% of these computers were not equipped to support the latest multimedia courseware—in other words, they could not combine text with advanced graphics, video or sound. Neither could many connect to an internal or external network. Factoring in new computer purchases in the 1994-95 school year, there are now on average 14 multimedia-capable computers per K-12 school or approximately 38 students per multimedia-capable computer. However, averages are misleading: the computers are not evenly distributed across schools. Surveys conducted by Quality Education Data, Inc., reveal disparities across schools based on socioeconomic and racial/ethnic status, although the situation has been corrected to some extent through federal funds and special grants available to underprivileged areas. For example, public K-12 schools with less than 20% of students qualifying for Chapter 1 funds (i.e., students from low income families) average nearly 8.6 computers (of any type) per 100 students while schools with over 80% average only 7.2 computers per 100

students. Likewise, schools with no minority students average 9.9 computers per 100 students while schools with over 90 percent minority students average only 7.3 computers per 100 students.<sup>27</sup>

Similarly, the external and internal network connections in schools today are limited. While 49% of schools have local area networks, half of those connect administrative computers. Fewer than 10% of these networks connected computers in all classrooms as of the 1993-1994 school year.<sup>28</sup> Likewise, although most schools have telephone lines, almost all are for administrative use; only 12% of classrooms have telephones.<sup>29</sup> Fewer than 5% of schools have high-speed, high-quality ISDN or T-1 connections,<sup>30</sup> and rough estimates from telephone companies indicate that up to one-third of schools are in areas where ISDN and T-1 connections are currently not available. Furthermore, while over 70% of schools have cable installed and up to 35% have satellite hook-ups, little of this infrastructure is currently capable of handling interactive applications.<sup>31</sup>

**Budget pressures.** To place the funding discussion in context, about 1.3% of the national public school budget is currently spent on instructional technology.<sup>32</sup> As discussed above, current spending would almost cover nationwide deployment of the Lab model, which would consume at most 1.5% of the nation's annual education budget. (This is a nationwide average; as mentioned above, the percentage of an individual school's budget going to technology would vary.) The Classroom model, on the other hand, poses a much greater challenge: the instructional technology budget would need to triple to meet the 3.9% of spending that this model would require. However, a continuation through 2005 of the recent technology spending growth rate of 16.5% per year would come close to reaching that 3.9% level—if this growth rate can be sustained. (See Exhibit 9: "Projected School Instructional Technology Spending.")

<sup>27</sup> *Technology in Public Schools: QED's 13th Annual Census of Public School Technology Use* (Denver, Colorado: Quality Education Data, Inc., 1994), pp. 26-27.

<sup>28</sup> Market Data Retrieval reports that, during the 1992-1993 school year, 49% of schools had a local area network for any use; see *K-12 Education Market Report* (Washington, D.C.: Software Publishers Association, July 1994), p. 31. QED reports for the 1993-1994 school year that 23% of schools had a network for instructional use, of which 18% (or 4% of all schools) connected classrooms; see *Technology in Public Schools*, supra note 27, pp. 76-77; see also *Educational Technology Trends, QED's 7th Annual Sample Survey of Technology Use and Purchase Plans in U.S. Public Schools* (Denver, Colorado: Quality Education Data, Inc., 1994), p. 56.

<sup>29</sup> Princeton Survey Research Associates, "National Education Association Communications Survey: Report of the Findings" (Washington, D.C.: National Education Association, 1993), p. 2.

<sup>30</sup> National Center for Education Statistics (NCES), *Advanced Telecommunications in U.S. Public Schools, K-12* (Washington, D.C.: U.S. Department of Education, Office of Educational Research and Improvement, February 1995), p. 13. Of the 49% of schools reporting wide-area network access, 3% report having a T-1 connection, and 4% an ISDN connection, suggesting that 3.5% of all schools have access to either one. In addition, 4% of the 49% reported access to "other" connections.

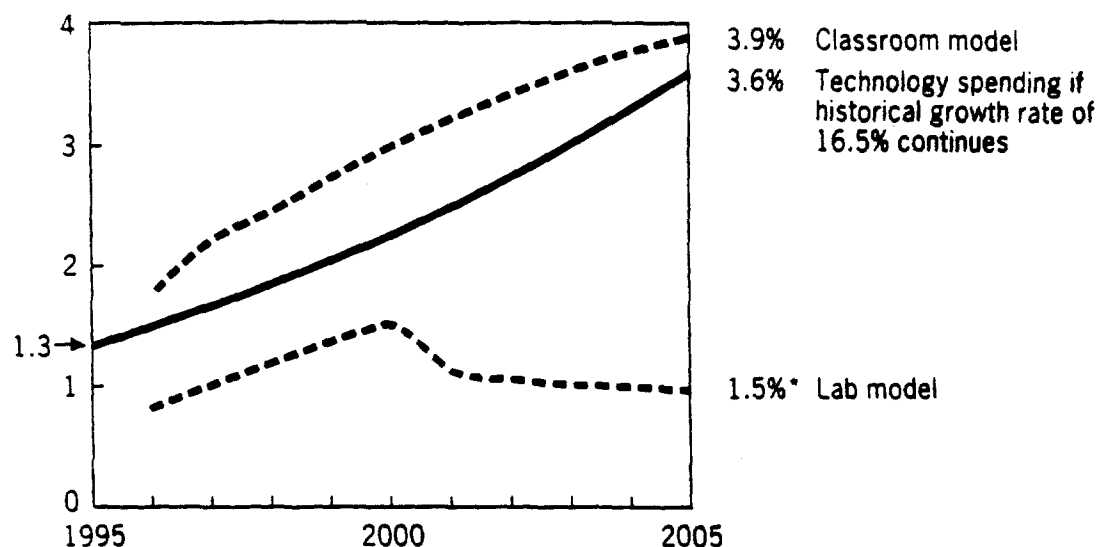
<sup>31</sup> Ibid., p. 7. Margaret Honey and Andrés Henriquez, *Telecommunications and K-12 Educators: Findings from a National Survey* (New York: Center for Technology in Education, Bank Street College of Education, 1993), p. 11.

<sup>32</sup> See Appendix C for the breakdown and derivation of this figure.

Exhibit 9

## PROJECTED SCHOOL INSTRUCTIONAL TECHNOLOGY SPENDING

Percent of public K-12 spending



\* In 2000, final year of deployment

Source: National Center for Education Statistics; Software Publishers Association; McKinsey analysis

Sustaining such a growth rate, however, will not be easy. The education budget is caught between upward pressures on spending due to demographics, inflation, and other demands, and downward fiscal pressures on government spending programs. The \$249 billion per year that is currently spent overall on public K-12 education is forecasted to grow at a rate of 5.6% per year through 2005. About 1% of this increase comes from predicted growth in the number of students, and 3% from inflation, leaving only 1.6% for all other increases in per-student spending.<sup>33</sup> And given mounting pressures for cuts in federal, state and local budgets, this projected 5.6% growth rate may not materialize, further constraining technology spending.

Other important demands for educational funds also will compete with technology for share of the budget. Basic repairs and facilities upgrades (estimated at \$101 billion) are a top priority for many schools, as are school security programs.<sup>34</sup> Mandated programs, such as compliance with federal requirements for asbestos removal and handicapped access (\$11 billion over the next 3 years) are also contributing to budget

<sup>33</sup> National Center for Education Statistics, *Projections of Education Statistics to 2005* (Washington, D.C.: U.S. Department of Education, Office of Educational Research and Improvement, January 1995), p. 83.

<sup>34</sup> Not all repair and upgrade expenditures are inconsistent with technology spending, however. In fact, retrofitting schools to accommodate technology can be effectively coordinated with some repairs and upgrades. See Ezra D. Ehrenkrantz, "Retrofitting in Increments: Redesigning Your School for Whatever the Future May Bring," *Electronic Learning* (February 1995), pp. 22-23.

**ESTIMATED POTENTIAL FROM COST REDUCTIONS****CLASSROOM MODEL**

<b>Element of Infrastructure</b>	<b>Major cost-saving mechanisms</b>	<b>Potential reduction in element cost Percent</b>	<b>Potential contribution to funding challenge Percent of public K-12 spending</b>
<b>Connection to school</b>	<ul style="list-style-type: none"> <li>• Special rates/subsidies</li> <li>• Volume purchasing by states</li> <li>• Share cost with other government agencies</li> </ul>	5-50 10-60 ?	0.05
<b>Connection within school</b>	<ul style="list-style-type: none"> <li>• Use of volunteers to pull cable</li> <li>• Volume discounts</li> </ul>	10 10	0.05
<b>Hardware</b>	<ul style="list-style-type: none"> <li>• Purchasing cooperatives at county or state level</li> </ul>	5	0.05
<b>Content</b>	<ul style="list-style-type: none"> <li>• Negotiated discounts in purchase price and alternative licensing agreements</li> <li>• Cooperative ventures with courseware developers</li> <li>• In-house curriculum development</li> </ul>	10 ? 	0.05
<b>Professional development</b>	<ul style="list-style-type: none"> <li>• Extensive peer training and support</li> <li>• Vendor-provided training and support</li> </ul>	} 5-40	0.20
<b>Systems operation</b>	<ul style="list-style-type: none"> <li>• Wide availability of best practices and "how-to" materials and sources</li> <li>• One-time repair contracts</li> <li>• Vendor-provided integration/operation</li> </ul>	} 2	~0.00
<b>Total potential contribution</b>		<b>10%</b>	<b>-0.40%</b>

Source: Interviews; McKinsey analysis

pressures.<sup>35</sup> Finally, teachers' salaries—currently 57% of educational spending—have increased faster than inflation over the past decade.<sup>36</sup> Technology requires funding not just for the initial installation, but also for ongoing operations, training, upgrade and maintenance costs. Locking sufficient funds into the budget over the long term implies that these budget battles will need to be fought year after year.

Despite these budgetary pressures, our analysis suggests that the funding challenge can be met through a combination of cost reduction, reprogramming existing funds, and additional initiatives from both private and public sectors. For example, the Classroom model could

<sup>35</sup> U.S. General Accounting Office, *School Facilities: Condition of America's Schools* (Washington, D.C., February 1995), pp. 5-7.

<sup>36</sup> From 1980 to 1993, teacher pay increased relative to inflation (20% higher). "Will Schools Ever Get Better?" *Business Week*, April 17, 1995.

be funded by the following combination of initiatives: maintaining the current spending rate on technology of 1.3%, capturing 0.4% through additional cost reductions (or a further 10% savings on purchases), reprogramming anywhere from 1% to 2% of closely related budget categories, and securing up to 1% in additional funds. The more successful the cost reduction and reprogramming initiatives are, the lighter the burden that will fall on securing alternative funds. The following list of funding suggestions is neither prescriptive nor by any means exhaustive.

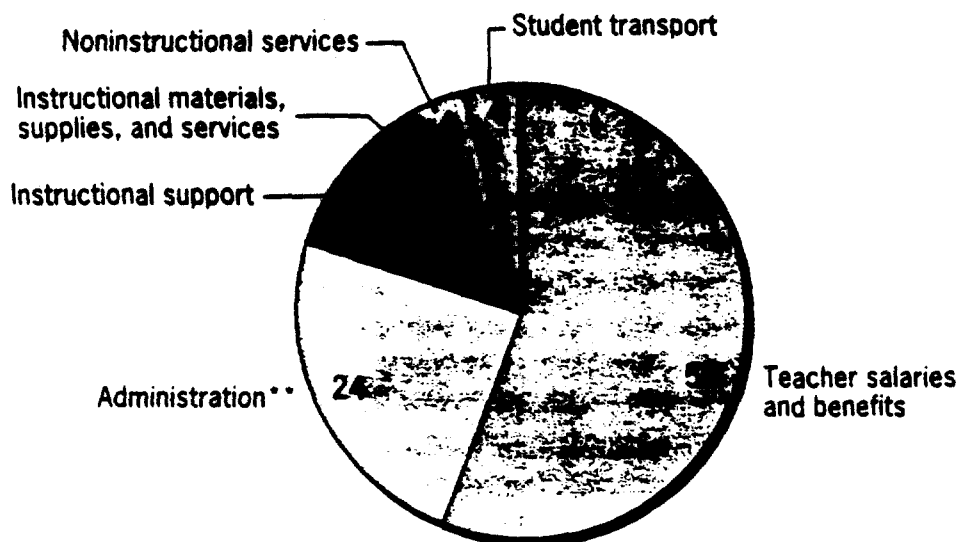
**Reduce costs.** One way to reduce the cost of deployment is to form buying consortiums at the state, regional, or national level to negotiate lower prices than a typical district could negotiate on its own. Such negotiation with equipment and service providers could reduce the cost of deploying the Classroom model by about 10%; these savings go beyond discounts assumed in the model. (See Exhibit 10: "Estimated Potential from Cost Reductions.") Likewise, securing donations of in-kind services from local community groups—free local area network installation, for example—represents another way to reduce individual schools' funding burden.

Cost reduction efforts should target the largest cost elements that can be affected: hardware, internal network installation, and professional development for teachers. Most proposals to date, however, have

Exhibit 11

# **DISTRIBUTION OF SCHOOL EXPENDITURES, 1992\*** Percent

■ Natural candidates for reprogramming



\* Based on California, Texas, New York, and Illinois

\*\* Includes General Administration 3%, School Administration 8%, Operations and Maintenance 10%, and other support 3%

Exhibit 12

# ESTIMATED POTENTIAL FROM REPROGRAMMING FUNDS\*

## CLASSROOM MODEL

Budget category	Assumption	Potential contribution to funding challenge Percent of public K-12 spending
Instructional material	Shift print materials to software	0.8 - 1.3
Instructional support	Shift part of job focus to selecting software/integrating technology	0.2 - 0.5
Discretionary spending on field trips, supplies	Shift to virtual field trips and technology supplies	0.1 - 0.4
Vocational training	Incorporate technology purchases (e.g., computer lab in favor of wood shop)	?
Total potential contribution*		1.1% - 2.2%+

\* Does not include reprogramming funds from "unrelated" spending categories (e.g., streamlining administrative expense to pay for technology)

Source: National Center for Education Statistics; Interviews; McKinsey analysis

focused on the connection to the school—for example, ensuring universal access to the Internet through telephone line or other connections. While such initiatives are important, they will not by themselves make much of a dent in overall funding needs.

**Reprogram existing funds.** A second set of actions focuses on shifting existing educational funds to new uses. Selected categories of the school budget are natural candidates for potential reprogramming in support of connecting schools (see Exhibit 11: "Distribution of School Expenditures, 1992"). Textbooks account for about half of schools' expenditures on "instructional materials, supplies, and services"—about 2% of total school spending. Some of these funds could be used for multimedia courseware and on-line instructional materials, supplementing (or replacing) traditional textbook purchases. Another 8% of school spending is currently devoted to "instructional support," such as instructional supervisors (e.g., the head of the math department). Some of these resources could be redeployed to address teacher training and support needs. For example, instructional supervisors could focus on helping teachers integrate technology-based tools into the curriculum.

Reprogramming funds within these natural candidate categories could contribute 1% to 2% to the technology budget (see Exhibit 12, previous page: "Estimated Potential from Reprogramming Funds"). In addition to this 1% to 2% from natural candidates, some general funding categories can also be reprogrammed. In Carrollton, Georgia, for instance, the district cut administrative staff by 20% to 30%, releasing funds for technology and connection within their schools. Some schools, such as those in the Hueneme District, have chosen to fund technology rather than teachers' aides.

**Secure additional funds.** A third funding option—and perhaps the most difficult—is to secure new sources of funding. Currently, state and local government funds cover 84% of the public K-12 education budget, but account directly for only 60% of technology spending (see Exhibit 13: "Sources of Public School Funds"). Some state and

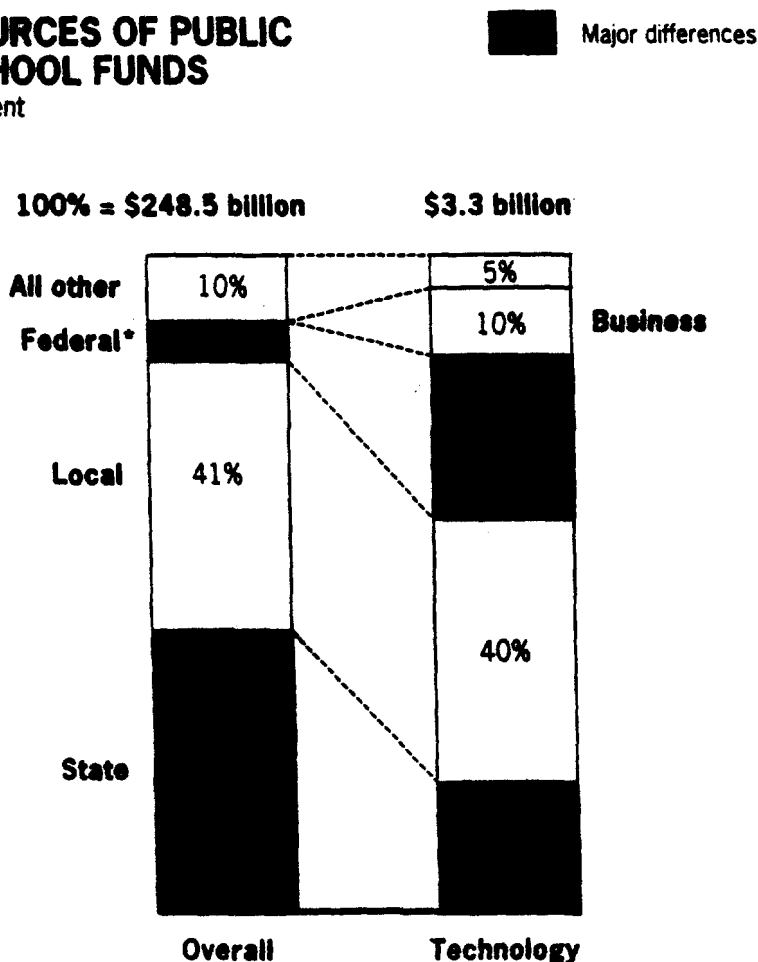
local governments have issued special educational bonds, increased taxes, and/or allocated lottery funds to cover investment in educational technology. A range of other funding sources have provided support for technology to date, including federal Chapter 1 and 2 funds.

Innovative schools and districts have also found a number of ways to raise money from local community groups, private industry, and foundations. Some schools and districts have been fortunate enough to be chosen as model schools or pilot sites for major equipment suppliers including telephone, cable, and computer companies. Others have received special grants from a range of sources, including private foundations. Some have set up entrepreneurial ventures such as developing and selling their own educational software. The Carrollton School District offers one good example of a creative approach to funding. (See sidebar, "Case Study: Carrollton School District, Georgia.")

Exhibit 13

## SOURCES OF PUBLIC SCHOOL FUNDS

Percent



\* Includes Title 1/Chapter 1; Title 6/Chapter 2; Job Training Partnership Act; bilingual and other programs

Source: U.S. Department of Education; Software Publishers Association; Education Turnkey Systems; CCA Consulting

In the last 4 years, leaders of the Carrollton City School District have attracted tremendous funding and technical support for their plans to introduce technology into the school system. Telecommunications, Inc. (TCI) has contributed in excess of \$1 million; IBM and the IBM Foundation have contributed nearly \$1 million; local businesses such as Southwire Company, Citizens Bank and Trust, Georgia Power, Southern Bell, Sony Music, Inc., and Peachtree Cable, Inc. have provided grants of \$500 to \$50,000 and helped to train teachers. The state of Georgia has contributed a grant of \$820,000 from a part of the Universal Service Fund created by Senate Bill 144, which took Southern Bell overcharges that would normally be refunded in small checks to consumers and created a \$50 million fund to build a telecommunications infrastructure for medicine and education in Georgia.

CASE STUDY  
**CARROLLTON  
SCHOOL  
DISTRICT  
GEORGIA**

How did the Carrollton City School District leadership attract all the support? Not by demonstrating a need any more acute than its fellow districts in the state. With three schools and 3,504 K-12 students, the Carrollton City School District looks pretty average from a purely statistical point of view. But the district leadership is light-years ahead of many when it comes to choosing a direction, galvanizing support for its goal, and finding ways to secure funding.

In 1984, school district administrators decided to get the entire community involved in determining the direction of education in Carrollton City. Since then, more than 300 members of the community have participated in articulating a vision for education, including a vision to create a community network that connects West Georgia College, libraries, Tanner Medical Center, county agencies, private homes, and the school system. To turn that vision into reality, the district initiated a series of events to market the vision to the full community and build support and momentum for it.

It invited prominent leaders from local government, business, the clergy, and education to talk about the district's vision for networking and how to finance it. Clear support from the city council, the mayor, the school board, and business followed. TCI identified Carrollton High School as its first National Showcase School and provided a video headend and cable to all school sites. IBM loaned every teacher a computer for a year and helped arrange long-term financing for a building-wide network that included eight file servers and 275 computer work stations, seven in every classroom. The district even got voters to approve a bond issuance to build a new school with all the state-of-the-art technology in place and, by redefining classrooms as "academic labs," was able to increase state funding by 20 percent.

But beyond the joint problem solving and funding that followed, the district has achieved an important intangible that will help it maintain the system—currently a \$600,000-a-year proposition. The high level of community involvement has created commitment to a shared vision of education and accountability outside the school and administration walls. This awareness continues to inspire creative ways of funding the system. (One idea currently under consideration, for example, is to sell file server access to the local cable company, which would then resell the access to households.)

With a decrease in the drop-out rate from 19 percent to just under 5 percent in 5 years, it appears that the community's efforts to create a more active and engaging learning environment through technology are paying off. The Carrollton City School District leadership and the community should feel encouraged that together they are taking the district in the right direction.

cover a wide range of topics, including basic computing skills, specific applications, curriculum integration, and networking. Teachers can receive college credit for some of the courses. Some of the training is compensated through regularly scheduled teacher in-service days and release-time training. The district's training program also includes a number of training courses and seminars provided at school sites, as well as support staff who are available to visit sites and provide "just-in-time" training and support as needed.

An interesting twist on teacher professional development is made possible by the technology and connectivity itself. For example, the "Online Internet Institute" is a newly formed initiative that is leveraging the Internet to bring together a group of 665 educators from school districts around the country during the 1995-1996 school year. These educators receive instruction on-line about integrating the Internet within their classrooms and supporting their peers in doing the same. This instruction is provided by on-line mentors and includes access to information resources and support for curriculum integration (e.g., lesson plans, technology suggestions).<sup>42</sup>

In addition to in-service development opportunities, some states and colleges of education are taking the lead in establishing higher standards of competency with technology and providing the resources—including equipment, course time, and expertise—to ensure better preparation of teachers entering the school system. For example, the School of Education at Northwestern Kentucky University is actively working on increasing the requirements for technology training beyond a one or three semester hour course. The School is investing in new technology infrastructure both for its computer lab and in support of its computer-aided classes, in which each student is provided a computer and modem for the semester. Most of this activity anticipates the implementation of a state-wide technology plan for the K-12 public school system.<sup>43</sup>

In Texas, the Houston Consortium is focusing on completely redesigning teacher education. The Consortium's effort to integrate technology into the pre-service education of teachers is particularly significant. Each prospective teacher is encouraged to purchase a laptop computer for lesson planning, telecommunications, record keeping, and instruction. The Consortium also supplies each participating K-12 school a telecommunications center and a portable multimedia station to be used by the pre-service (and in-service) teachers. Finally, the Consortium also provides both individual laptop computers for the professional development of up to 6 faculty members and a computer classroom (5 computers for instruction and 10 laptops for students) to each participating university or college of education. Training is provided

<sup>42</sup> Interviews with Bonnie Bracey, cofounder of the Institute, September 1995.

<sup>43</sup> Connie Carroll Widmer and Valeria Amburgey, "Meeting Technology Guidelines for Teacher Preparation," *Journal of Computing in Teacher Education*, vol. 10, no. 2, pp. 12-17.

## TECHNOLOGY SKILL STAGES FOR TEACHERS

Skill stage	Description	Professional development needed
<b>Entry</b>	Teachers struggle to cope with technology and new learning environment, or have no experience at all	—
<b>Adoption</b>	Teacher moves from initial struggle to successful use of technology at a basic level (e.g., can use drill and practice software)	• 30 hours training
<b>Adaptation</b>	Teacher moves from basic use to discovery of potential in a variety of applications. Teacher has good operational knowledge of hardware and can perform basic troubleshooting	• 45+ hours training • 3 months experience • Just-in-time support
<b>Appropriation</b>	Teacher has mastery over the technology and can use it to accomplish a variety of instructional and classroom management goals. Teacher has strong knowledge of hardware, local area networks, and wide-area networks	• 60+ hours training • 2 years experience • Just-in-time support
<b>Invention</b>	Teacher actively develops entirely new learning techniques that utilize technology as a flexible tool	• 80+ hours training • 4-5 years experience • Just-in-time support

Note: Required times are cumulative

Source: U.S. Congress, Office of Technology Assessment; Teaching Matters

both in the use of the technology and in the integration of the technology into the curriculum. To date, the results have been extremely encouraging, and the organizers and participants continue to pursue multiple initiatives in order to make sure that "graduates from the programs of the participating colleges of education will enter the classroom as new teachers with knowledge and skills in the use of technology that will match their knowledge of subject matter and their skills in teaching children."<sup>44</sup>

As examples like these suggest, no one model for teacher professional development will be right for all schools, districts, and states. However, we believe that some basic principles will help many schools get started and some broader actions could provide valuable support to local school and district initiatives.

A first step is to set accurate expectations as to how long effective professional development is likely to take. Exhibit 14, "Technology Skill

<sup>44</sup> Richard Alan Smith, W. Robert Houson, and Bernard Robin, "Preparing Preservice Teachers to Use Technology in the Classroom," *The Computing Teacher* (December/January 1994/1995), p. 59.